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MICROSCOPIC INVESTIGATIONS RELATING TO TEA AND ITS ADULTERATIONS.

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Nothwithstanding the numerous microscopic investigations which have been made during the last twenty years relating to the external and internal structure of the tea-leaf, there seems to be a necessity for further investigation in this direction, judging from my recent observations in this line of research.

In making preliminary examinations of tea-leaf dissections, I discovered peculiarly formed isolated cells, polarizing bodies, seemingly having no connection whatever with the general cell-structure of the leaf. On looking up the various writers on food adulterations, I found the following notice of these peculiar cells, termed idioblasts, in Blythe's Analysis of Foods :

" Idioblasts are long, tough, tenacious, branched cells which seem to act as pillars or beams, keeping the two layers of the leaf apart. They do not occur in any other leaf with which the tea-leaf is likely to be confused, so that their presence would indicate tea ; their absence would point to foreign leaves. A very convenient method of detecting idioblasts is given by Moeller : Small fragments of the leaf are warmed in a very strong solution of caustic potash and then placed under the thin covering glass and pressed firmly." They must be viewed under suitable powers of the microscope. Botanists have given various names to the idioblasts, such as " stone-cells " (so-called after the stony bodies in the flesh and stalk of many pears which are composed of them), scleroblasts, and sclerenchyma. Their function is not positively known. DeBary, Sachs, Bessey and others give full information in their respective botanical works regarding the presence, structure, and supposed use of these cells. The general structure of the tea-leaf presents to the ordinary observer nothing of peculiar importance, but on closer inspection, with high powers of the microscope, an experienced microscopist will easily detect, especially by means of polarized light, these peculiar isolated cells in the transverse and longitudinal sections of the midrib of the leaf, but especially are they found scattered in great numbers, irregularly, throughout the body of the leaf. The stone-cells of the Camellia Japonica, which belongs to the tea family, differ slightly from those found in the tea-leaf. The stone-cells of the former are more fleshy, and in my experience seldom exhibit large openings in their centers, such as are described by DeBary, (see his "Comparative Anatomy of Phanerogams and Ferns," page 13). The leaves of some species of Camellia, of which it is said by Carpenter that there are many species, are said to have been used as adulterants of tea by the Chinese merchants about 20 years ago. The leaves of the species japonica are very thick and fleshy as compared with the tea-leaf proper, and therefore may be distinguished from the former.

The presence of stone-cells or idioblasts in tea-leaves, and their absence in all other plant-leaves used as adulterants of tea, according to Blythe, if correct, is a very important factor to begin with. My experience, in this respect, agrees with that of Blythe. I have examined the following leaves used as adulterants of tea, with the view of ascertaining whether stone-cells are contained in them, but have found none, viz: Willow, Sloe, Beech, Paraguay Tea, Ash, Black Currant, two species of Hawthorn (one the common English Hawthorn), and Raspberry. I find, however, that many of the leaves above mentioned contain a class of crystals not observed in tea-leaves, viz: crystals of oxalate of lime, while the Willow and some other leaves used as adulterants contain raphides, starry forms common to the tea-leaf. Raphides are aggregations of acicular or needle-like crystals appearing in star-like forms, and are common to many plant-leaves used in the adulteration of tea. Blythe has alluded to them.

While it is well known that only the small or young leaves of the tea-plant are generally employed in the commercial product, the structural characteristics of the larger leaves are more easily differentiated, and are quite suggestive of what to expect in the more delicate forms. Students should begin with the larger leaves. For these investigations leaves from the living plant are required. I have readily obtained them in all stages of growth from the propagating grounds of this department.

"The mesophyll or parenchyma of the tea-leaf contains two kinds of cells, the one being a very regular single or double row filled with chlorophyll, just beneath the upper epidermal layer, whilst a spongy parenchyma containing large spaces occupies the rest of the leaf thickness."—*Blythe.* Having ascertained the order and forms of cell-arrangement in the mature leaf, the investigator proceeds with the knowledge thus acquired to the more delicate teas of commerce. The first difficulty met with in experimenting with the teas of commerce results from the changed condition of the leaf. The leaf in its natural state is strong, and without curl, while as manufactured it is dry, fragile, and much of it in the form of a powder. Its most favored form is that of a compact roll. With a little experience these artificial conditions and attendant difficulties are easily overcome by patient perseverance. The simple process of infusion will remove much of the difficulty. Tea-leaves found entire should be separated from the fragments. All fragments should be examined. It is a good plan to sort out the different forms, placing each lot of a similar kind by itself. Many of the fragments will exhibit the edges of the leaves entire. Secure a sufficient number of these fragments by means of any suitable cement on slips of glass 3 x 1 inch, and examine the indented edges (serrations), using low powers. Make a drawing of them and compare the serrations with those of the leaves of the true tea-plant. Cross and longitudinal sections should be made of the tea-leaf and mounted in the usual way for microscopic observation, comparison, and for purposes of photography. Portions of the upper and under epidermis may be easily removed by any of the well known published methods. The lower surface of the leaf contains "breathing pores" (stomata) (see Plate 1, Fig. 1). The green portion of this figure represents the palisade cells charged with chlorophyll. Fig. 2, represents a single stone-cell or idioblast highly magnified, as observed within the fleshy part of the leaf. Plate 2, Fig. 3, represents stone-cells under lower powers, together with a view of some of the raphides, oil globules, etc. Fig. 4, the upper epidermal layer of the tea-leaf. I have not observed stomata in it. The stone-cells average about the one-hundredth of an inch in length and exhibit prismatic colors when viewed by polarized light.

The next step is to dissect the midrib of the tea-leaf, making fine longitudinal sections. Stone-cells are frequently met with in the central portion of the midrib. I have found in a section only one-quarter of an inch in length five of these peculiar cells, as represented in Plate 3.

Plate 4, Fig. 5, represents a cross-section of a leaf of the Camellia Japonica, showing the position of the stone-cells within it. Fig. 6, a cross-section of the tea-leaf of commerce. Fig. 7, the lower epidermal layer of a leaf of Camellia Japonica, showing the stomata. The green cell-structure represents the palisade cells containing the chlorophyll or coloring matter. Plate 5, Fig. 8, is an enlarged view of the tea-leaf, showing the peculiar venations; 9, leaves of the Black Currant, said to be used as an adulterant of tea. Plate 6 consists of outline sketches of some of the leaves said to be used as tea adulterants, viz: Willow, Ash, Paraguay Tea, Beech, Hawthorn, Sloe, and Camellia Japonica. One specimen of the true tea-leaf also appears on same plate. These leaves vary much in depth of color. In the natural state at maturity they are of a dark green, particularly those of the Paraguay tea-plant. The Beech is a light yellowish green, the leaf of the Sloe is dark green and of a coarse woody character as compared with the tea-leaf. By curing and infusion all these leaves assume a dark greenish-brown hue. Plates 7 and 8 represent the serrations of the tea-leaf contrasted with those of leaves used for purposes of adulteration. It will be seen that they are quite distinctive. Rasberry leaves are said to be used in large quantities for tea adulteration in this country. This will be investigated.

How to detect stone-cells in the Tea-leaf.

I have tested Moeller's method, but find it defective in one particular. He says: "Treat the leaves with a warm and strong solution of caustic potash and mount with a thin covering glass and press firmly." The student will experience great difficulty in discovering the idioblasts by this method. Modify the method as follows : Boil the tea or other suspected leaves in a solution of strong caustic potash or soda for three minutes, allow this to cool, remove a leaf or portion of a leaf as the case may be, by means of forceps, and place it on a slip of glass 3 x 1 inch. Place a second slip of glass of the same dimensions over it and in contact with the first slip, thus covering the specimen, press firmly, using *slight friction*, so that the leaf will appear as a mere stain between the glasses. This method, while it disintegrates the general cell-structure, does not impair the outline of the stone-cells or idioblasts, of which numerous groupings may be observed. By this method tea-leaf hairs may sometimes be observed in great numbers, as they are not injured by the potash. Plant-leaf hairs are frequently distinctive, indicating sometimes the species of plant to which the leaf belongs, and are a factor to be considered in these investigations.

In order to become familiar with the general appearance of the entire cell arrangement of the tea-plant it will be necessary to give considerable time to the work familiarizing one's self with the many forms observed under high and low powers of the microscope, noting not only the cell forms but the relative size of the cells. This will be found particularly valuable in making examinations of what is sold for tea-dust, which may contain very little tea and consist mostly of raspberry leaves or other worthless substance, reduced to a fine powder, purposely to make their detection difficult; but when it is considered that a particle of this so-called tea-dust measuring only the one-hundredth of an inch in diameter, if magnified 300 times, will appear under the microscope, three inches in diameter, it will be seen that the cell-structure may be easily observed and its character ascertained. I have recently discovered in a certain sample of tea marked evidence that it was composed largely of a thin-leafed species of Camellia. In this case the sample was probably compounded in China, where this character of adulterant was formerly used on a large scale.

The early investigators of adulterated food supplies have enumerated many substances found in tea, but it is acknowledged that many of the adulterants formerly used are now discarded. The truth is, that many of the adulterants were so easily detected, and punishment of the offender followed so surely, that the mixer was forced either to abandon the practice or so modify it, by the admixture of harmless substances, that the question now resolves itself simply into the consideration of relative cost. That is to say, the principal question which interests the consumer, and especially the poorer classes, relates to economy, and not to the poisonous character of the adulterant. If a person should pay fifty cents for a pound of tea, containing half a pound of black currant leaves costing two cents, it is evident that the purchaser has paid for half a pound of tea nearly one dollar. The poor are the greater sufferers in this way, as they generally deal on credit and frequently with irresponsible persons. It is to prevent this organized system of robbery on the part of irresponsible persons that has induced Congress to devise means to protect the purchaser of food-stuffs from the admixture of worthless compounds, even if they may not be injurious to health.

Most of the teas shipped from Japan to the United States are now artificially colored. Formerly this was not the case. In the early years of the trade, say from 1859 to 1869, the manipulation of Japan teas by the exporter was confined to a simple refiring, which was necessary in order to cure the leaf sufficiently to enable it to endure transportation through the tropics and to retain its qualities while in store. This process alone required large establishments, a considerable plant, and important outlays for fuel and labor. But the leaf was improved by the expenditure, and Japan teas were then shipped in their natural condition and honestly called "uncolored." About 1870, however, consumers began to call for a higher color than any natural process would furnish, and although this demand was long resisted by the shippers in Japan, and at some loss to themselves, yet ultimately it prevailed and for some years past artificial coloring has been the rule, so that Japan teas which are naturally of a blackish green color are now made to resemble bluish gray or grayish blue teas shipped from China as "green teas." The materials used to produce these unnatural shades are not very pernicious, it is said, being nothing worse as a general rule, than indigo and gypsum, but they certainly add nothing to the value of tea-leaves for drinking purposes, while they do add considerably to their cost. There is nothing to be said in favor of the practice, except, that dealers in America prefer teas of that description. Their doing so is probably explained by the fact that in teas so colored coarse leaves may pass without detection, and this is no doubt the cause of the gradual deterioration of the quality of the Japan teas exported to America during recent years. The adulteration will probably continue as long as American consumers buy their teas in accordance with the appearance of the leaf, regardless of their infusive qualities, and as long as the simple secret of making the infusion is so little understood in our country. To the Japanese, who value tea for its fragrance and delicacy, and who are careful to draw these qualities from the leaf by the use of pure water and nice vessels, the article is an abomination, and they naturally conclude that the quality of the leaf which is subjected to such treatment is not important. According to a late United States Consular Report, the American demand for the uncolored teas known as "basket-fired" has latterly increased, and it would be as advantageous to the consumer in the United States, and it would gratify most shippers in Japan, if this inclination to return to honest, uncolored teas were to become general, for it would certainly result in greater discrimination in the picking and preparation of the leaf in Japan and would afford consumers better teas at lower prices, would restrict the supply to good teas only, and would revive the favor which Japan teas formerly enjoyed in the American market as compared with the highly colored teas of China.

In thus pointing out the marked characteristics of the tea-leaf, and of leaves used as adulterants, the microscopists of the country engaged in this line of work will be able to acquire a knowledge of the simplest method of investigating tea and its adulterants.